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(71) Applicants
Labora Mannheim GmbH für Labortechnik, Sandhofer Strasse 176, D-6800 Mannheim 31, Federal Republic of Germany.
(72) Inventors
Reinhard Blumel
Jurgen Denker
Ernst Markart
Werner Trapp
Michael Tutzer
Reinhard Woznik
(74) Agents
J. Miller & Co.

(54) Feeding test strips through an evaluating device

(57) A device for evaluating test strips (11), having test areas (25) comprises a strip carrier including a drum (1) rotated incrementally each time a reciprocable measuring head (17) reaches the end of its stroke. A plurality of receivers (9) for test strips (11) are arranged on the drum parallel to the axis of rotation and a reflex photometer measures the reflection capacity of the test areas by means of the measuring head (17), which is slidably arranged on a guideway (59) parallel to the axis of rotation of the drum and is coupled by an articulation (75,77), deflectable transverse to the direction of movement, to an endless pulling element (73). The endless pulling element is arranged to be driven unidirectionally. A switching gearwheel (83) is in rotary communication with the drum (1) and a switching arm (81) is coupled to the endless pulling element for incrementing the switching gearwheel.

FIG.1

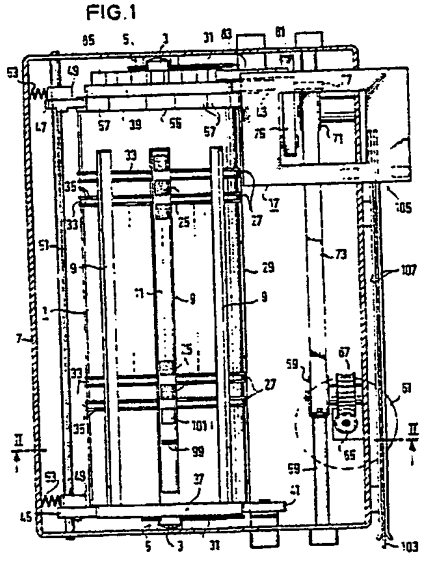

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FIG.1

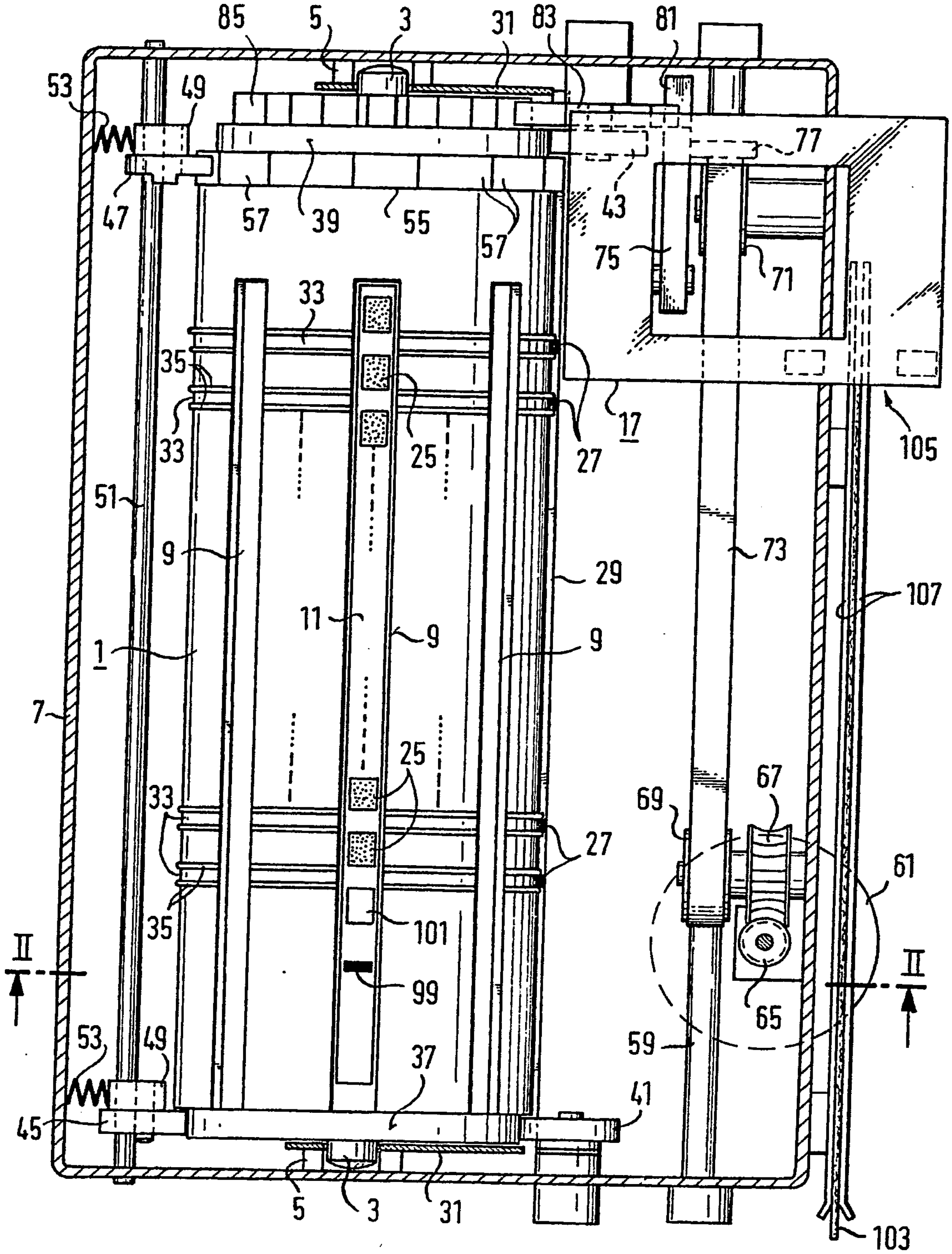

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FIG. 2

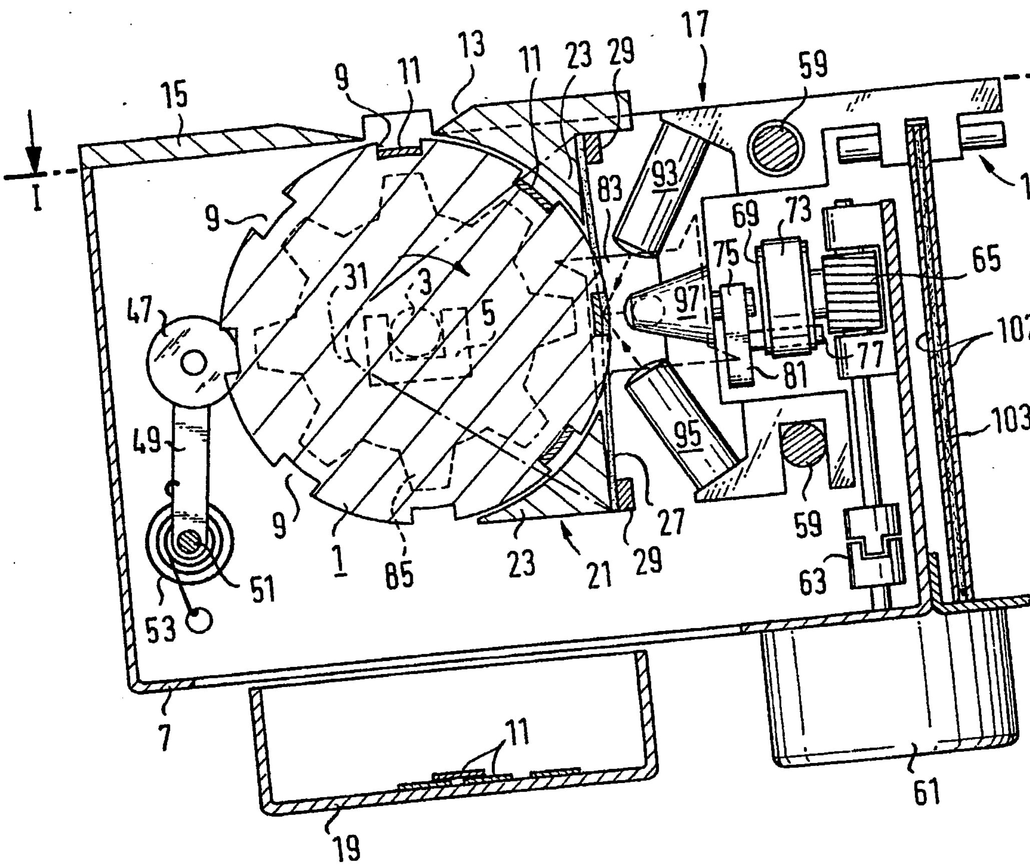
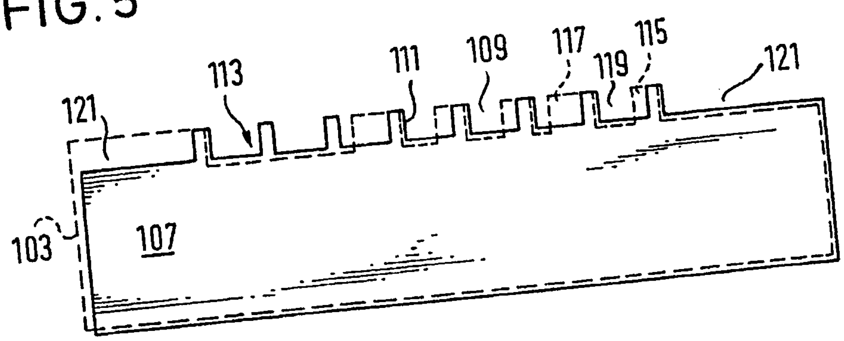


FIG. 5



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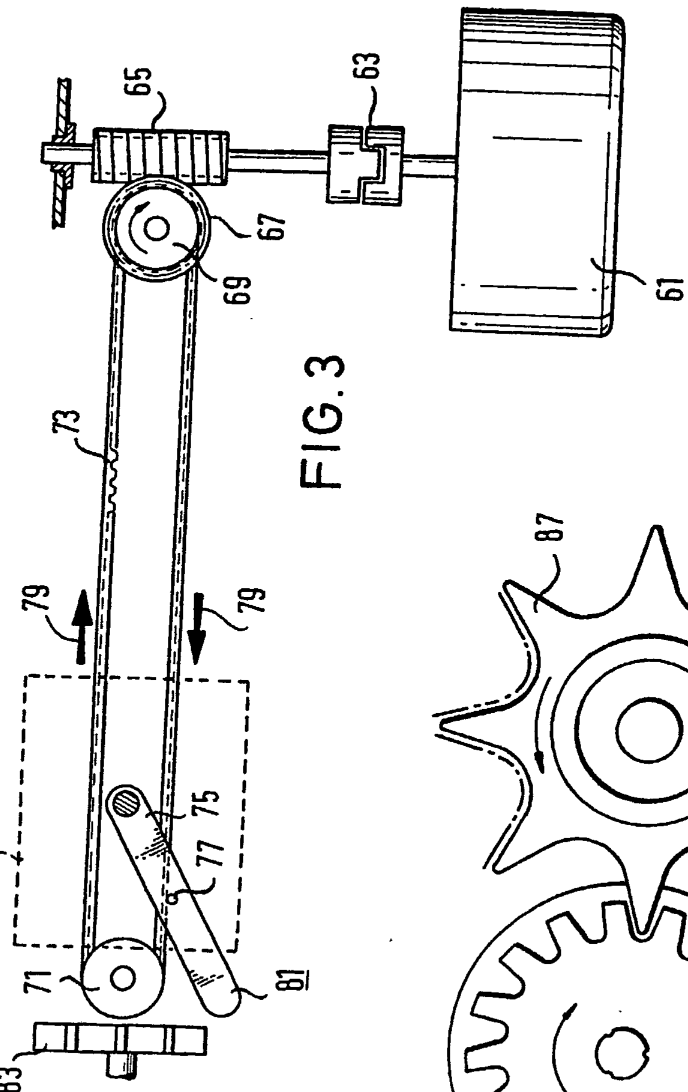

FIG. 3

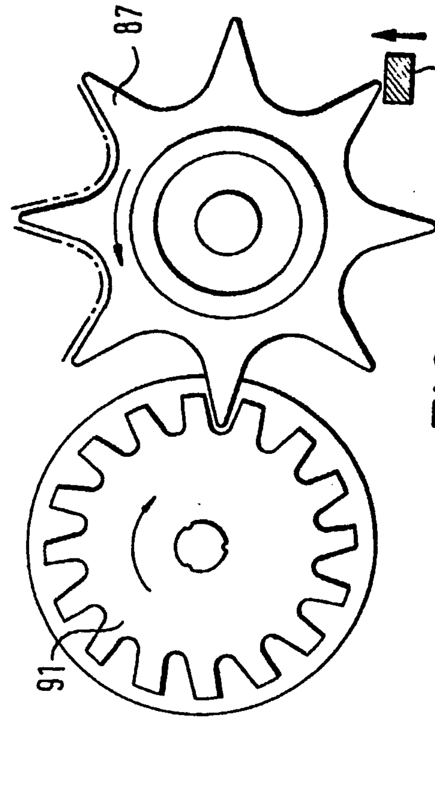

FIG. 4

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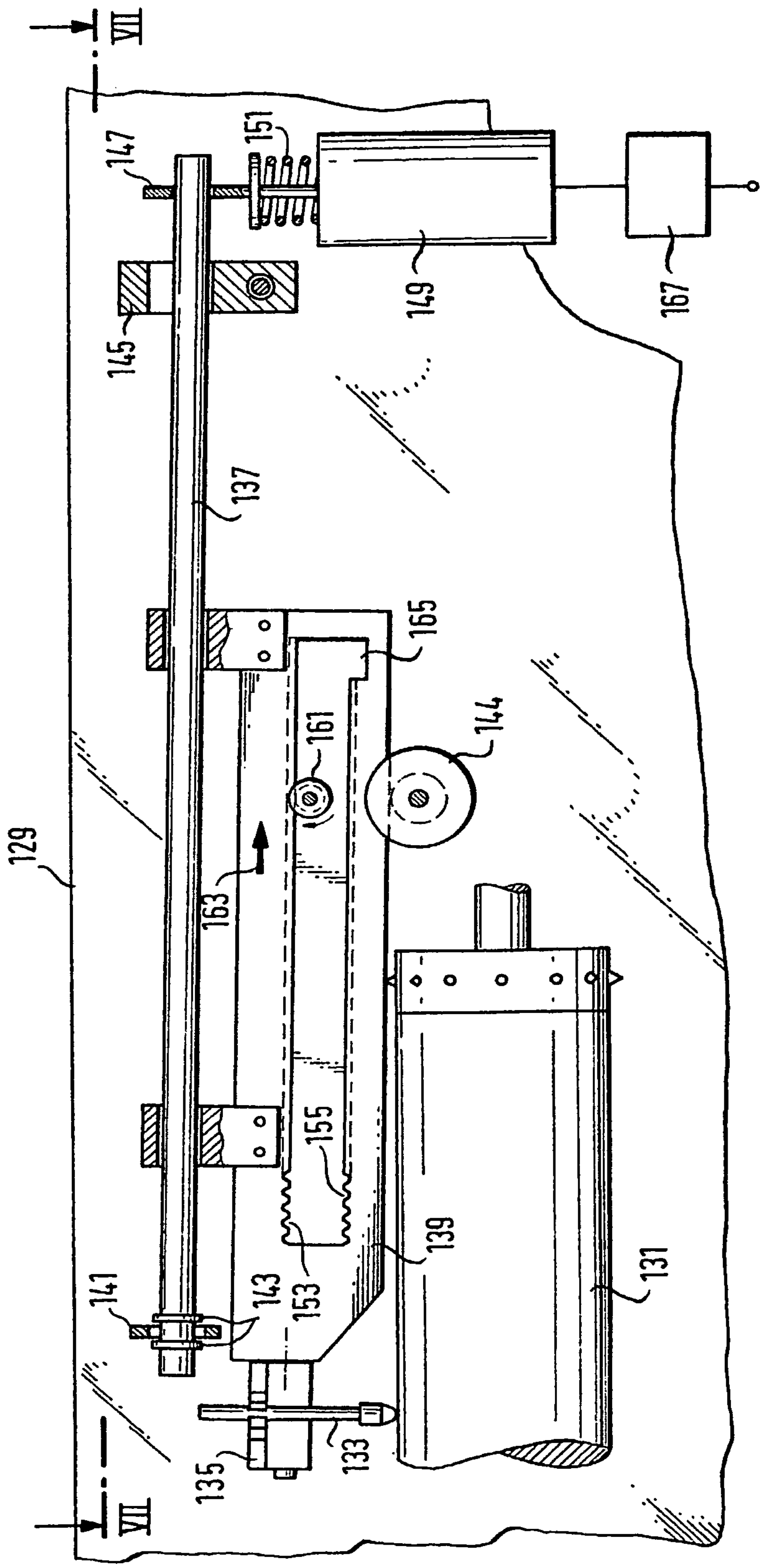

FIG. 6

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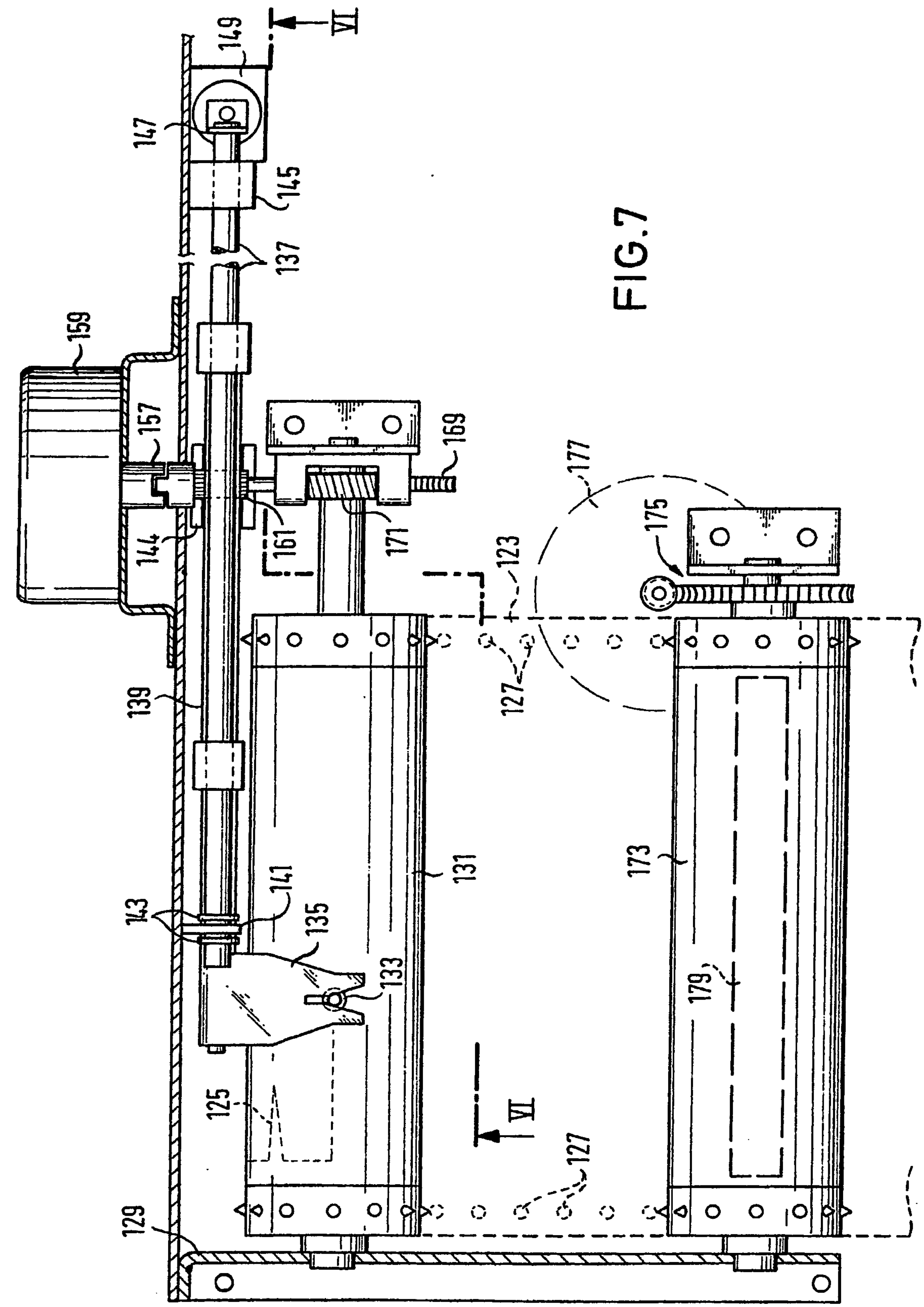

FIG.7

SPECIFICATION

Device for evaluating test strips

This invention relates to devices for evaluating test strips, for example, urine test strips, whose test areas are arranged beside one another along the test strip.

Urine test strips are an aid to medical diagnosis. They contain test areas which discolour visibly with certain substances contained in urine; the discoloration corresponding to a pathological concentration indicates an organic trouble. The test strips contain, in each case, several test areas which respond specifically to different substances in the urine. The chemical reactions which lead to discoloration in the test areas require a certain time, so that the colour forms only gradually. The dyestuffs formed are, in many cases, not stable and change through atmospheric oxygen or the action of light. The colour and colour intensity of the test areas which are a measure for the concentration of the substance which is to be analysed must therefore be observed within a defined space of time after immersion of the test strip in the urine. The estimation of the concentration is in many cases effected through visual comparison with colour scales.

The human eye is not equally sensitive to all colours and the depth of colour as measure of the concentration of the substance is evaluated differently by different individuals. Evaluation results which are independent of the evaluator can be obtained with the aid of an evaluation device for urine test strips which is known from German Offenlegungsschrift No. 25 57 872. This evaluation device measures successively, with the aid of a reflex photometer, the reflectivity of the individual test areas of a test strip. The reflex photometer has a measuring head with a light source which illuminates the test areas vertically with monochromatic light and an integrating globe (Ulbricht globe) which absorbs the reflected light. In the integrating globe there is arranged laterally to the test area a photocell which measures the intensity of light in the integrating globe. The test strip to be evaluated lies in a receiving trough of a transporting carriage which is moved through in longitudinal direction of the test strip under the measuring head of the reflex photometer by a drive motor.

In order to ensure unambiguous evaluation results, the reflectivity must always be measured an unchanging, predetermined length of time after the immersion of the test strip in the urine. To ensure this, the known evaluation device described above contains a timer which is started at the point in time of immersion and does not set in motion the carriage with the test strip until after the expiration of the predetermined length of time. Since the carriage can only accommodate one single test strip, the whole of the predetermined length of time must elapse before a further test strip can be evaluated. The length of time usually is of the order of one minute, so that the known evaluation device works relatively slowly and, in particular, is not suitable for series investigations in which larger numbers of test strips are to be evaluated.

The present invention seeks to provide a simple evaluation device for test strips, in particular urine test strips, which can evaluate the test strips automatically and with increased evaluation frequency of the test strips vis-a-vis known evaluation devices.

The present invention also seeks to issue in documentable form the measured values which are obtained. Furthermore, it is desirable that the issued value should be co-ordinated with, or capable of being co-ordinated with, a graduated scale, for example with normal or pathological concentrations. Moreover, it is advantageous so to design the device that an unambiguous co-ordination of specimen and documented value can be effected simply and without error.

According to the present invention there is provided a device for evaluating test strips, for example, urine test strips, having test areas arranged beside one another along the test strip, the device comprising: a strip carrier including a roller which is rotatably mounted in a chassis and on which a plurality of receivers for test strips are arranged, in staggered manner, parallel to the axis of rotation in the peripheral direction of the roller; a reflex photometer which measures the reflection capacity of the test areas by means of a measuring head; a drive device which moves the measuring head and the strip carrier relative to one another in the longitudinal direction of the test strips, the measuring head being slidably arranged on a guideway parallel to the axis of rotation of the roller and being coupled by articulation means, which is deflectable transverse to the direction of movement, to an endless pulling element of the drive device, the endless pulling element being arrnged to be driven unidirectionally; a switching gearwheel in rotary communication with the roller; and a switching arm coupled to the endless pulling element for switching forward the switching gearwheel.

In such an evaluation device, the movements of the roller and of the measuring head are compulsorily synchronised with one another. For drive, there suffices a single motor which moves the endless pulling element in unchanging direction in order to move the measuring head to and fro along the guideway and to switch the roller from one measuring position to the next. The speed of rotation of the roller is so chosen that the test strips are rotated from an insertion position of the test strips into a measuring position during a predetermined length of time which must elapse from the immersion of the test strips into, for example, the urine under evaluation. The frequency with which successive test strips are evaluated is independent of this length of time and is only determined solely by the number of receivers provided between the insertion position and the measuring position on the roller. The axis of rotation of the roller preferably runs horizontally; the insertion is on the upper side and the measuring position is at the side of the roller. After running

through the measuring position, the test strips on the underside of the roller automatically fall out of their receivers, which may be trough-shaped, and the test strips fall into a collecting container under the receivers. The drive of the endless pulling element may be effected intermittently; preferably, however, the speed of the endless pulling element is so adjusted that it is continuously driven and, despite this, the predetermined length of time for the transportation of the roller can be adhered to. The endless pulling element may be constructed as a chain, belt or toothed belt.

Two opposed sections of the endless pulling element may be mounted at a distance from one another. The articulation means, which couples the measuring head to the endless pulling element, compensates the thus changing distance of the endless pulling element from the measuring head. The articulation means could, for example, be constructed as a pivot which is mounted slidably in a guideway and joined to the endless pulling element. Constructionally simpler are embodiments in which the articulation means comprises a plurality of rods which are hinged at spaced apart points to the endless pulling element and to the measuring head. This embodiment enables a further constructional simplification of the device when the switching gearwheel is arranged beside a deflecting roller of the endless pulling element, the switching arm being held on the rods.

Preferentially, the rods and the switching arm are constructed in one piece. The switching gearwheel may be arranged on the side of the deflecting roller which faces away from the endless pulling element so that the switching arm, in operation, goes past the deflecting roller. In this manner the actuating stroke of the switching arm can be enlarged and better adapted to the dimensions of the switching gearwheel.

The switching gearwheel may be joined directly to the roller. In particular in the case of large roller diameter this, however, may lead to difficulties when, as is necessary in many embodiments, the switching gearwheel should project over the periphery of the roller. Here, embodiments have proved favourable in which the switching gearwheel is mounted for rotation about an axis parallel to the axis of rotation of the roller on the chassis and meshes with a gearwheel which is held coaxially on the roller. The length of action of the switching arm and the number of teeth of the switching gearwheel are preferably such that the switching gearwheel is capable of being switched forward by at least two teeth per switching movement of the switching arm. In this manner, it is possible to accomplish relatively large switching angles of the switching gearwheel in the case of continuous engagement of at least one tooth of the switching gearwheel in the gearwheel held on the roller.

The receivers of the test strips in the roller are preferably constructed as troughs into which the test strips are merely inserted. In order to secure the test strips in the receivers of the roller it has proved favourabl to provide a comb which is stationary relative to the chassis and whose fingers between the test areas in the peripheral direction of the roller grip round that part of the roller which faces the measuring head. In this manner the test strips are fixed not only during transportation from the insertion position into the measuring position but are also definitely held fast during the actual measurement. The fingers need not lie elastically against the entire periphery of the roller; it suffices when, in the measuring position, they press the test strip resiliently into the receiver. A constructionally simple embodiment of such a comb is obtained when that part of the comb which in a measuring position holds the test strips in the respective receiver is formed by filaments which are stretched tangentially lying against a roller vertically to its axis of rotation. The securing points of the filaments may be slightly staggered towards the axis of rotation of the roller so that there results the elastic contact pressure force by reason of the intrinsic elasticity of the filaments. Suitable, for example, are plastics filaments. The roller may have peripheral grooves for guiding the filaments. The peripheral grooves may also be formed by peripheral ribs arranged in pairs at a distance from one another. Since the filaments, like the roller, come into contact with the test strips immersed, for example, in urine, the roller, together with a holder for the filaments, may form a structural unit which is removable from the chassis.

It is important for the measuring accuracy of the evaluation device that the measuring head be mounted with unchanging distance from the surface of the roller. For this purpose, the axis of rotation of the roller must run exactly parallel to the guideway. The parallelism may in constructionally simple manner, even in the case of rollers which can be removed from the chassis without major assembly and dismantling work, be achieved in that the roller may have, on axially opposite sides, guide surfaces which extend in the peripheral direction for guide rollers which are rotatably mounted on the chassis and which determine the distance from the guideway of the measuring head, pressure rollers lying resiliently against that side of the roller which faces away from the guide rollers, a shaft of the roller being mounted in trestles which are open transverse to the shaft. The roller, therefore lies merely on the trestles; the correct distance of its axis of rotation to the measuring head is ensured by the guide rollers.

The reflectance spectra of the test areas responding to various substances in the urine generally differs from one another. In particular, the maxima of the reflectance lie at different wavelengths. The light source of the measuring head of the reflex photometer shoud, therefore, preferably emit monochromatic light with the light wavelength corresponding to the maximum of the reflectance. It would be conceivable to put, in front of the light source, filters which are in each case suitable for this purpose.

In a preferred embodiment of the measuring head, which also possesses importance independent of the hereinbefore described device, the measuring head is provided with a photocell arranged over the reflection surface of the test areas and at least two focusing, monochromatic light sources of different light wavelength which are arranged laterally to the

photocell, the light rays of which sources are, in operation, directed obliquely at such angles to the reflection surface that its directly reflected light ray goes laterally past the photocell. Such a measuring head, although it can measure at at least two light wavelengths, has small dimensions and works with sufficient accuracy. The reception direction of the photocell may be aligned normally to the reflection surface. Here, it has been found that the distance of the plane, light-absorbing surface of the photocell can be so far approximated to the reflection surface of the test area that the light-absorbing surface shows sufficient integrating effect. For reasons of space requirement, the light incidence angles of the light sources are preferably equal. Thus the light rays in the foot of a perpendicular directed by the photocell on to the reflection surface may impinge on the reflection surface. The reflectivity of the test area of the test strips usually employed in the visual comparison with colour scales can be best utilized, in terms of measuring equipment technology, when the one light source emits red light and the other light source emits green light.

In order to be able to use the device in as versatile a manner as possible, it should be so designed that test strips with varying number and combination of test areas can be evaluated. In so far as the reflex photometer of the evaluation device as a measuring head which is adjustable to various wavelengths, the measuring head should, for each test area of the test strip, be adjustable to optimum wavelength. These conditions can be fullfilled in constructionally simple manner in an embodiment of the measuring head, which possesses importance independent of the heretofore device, where the measuring head carries transmitter and receiver of a light barrier between which there is a diaphragm which cannot be removed from the device and an exchangeable pilot card, the diaphragm and the pilot card being arranged to control the drive device and/or the reflex photometer and having flush or at least partially overlapping windows for the light ray of the light barrier so that uniformly one of the two edges of the windows provided in the diaphragm is exposed and is arranged at the distance of test areas of the test strip to the corresponding edge of a neighbouring window. The edges of the windows in the diaphragm which cannot be removed from the device, which edges are arranged at the distance of the test areas of the test strip, align the measuring head relative to the test areas of the test strip. The exchangeable pilot card more or less covers the windows of the diaphragm which cannot be removed from the device; the extent of the coverage may contain additional information as to whether or not the test strip contains a test area assigned to the window being scanned at that moment and with which light wavelength this test area is to be scanned. This embodiment of the control of the device can also be utilised in evaluation devices other than those hereinbefore described.

Of particular importance is an insuance of the measured results which avoids errors of transmission and conversion. This issuance may, for example, be effected *via* a suitable calculator and digital printer. Preferably for recording measured results, a line recorder is provided whose recording stylus is held on a carriage which is slidably guided along a guideway transversely to the advancing direction of a recording carrier, the carriage having two drive surfaces which face one another and are parallel to one another and to the direction of movement of the guideway, between the drive surfaces there being engaged a drive wheel which is rotatably mounted, non-removably from the device, which is driven in the same manner by a motor and whose diameter is smaller than the distance of the two drive surfaces, the guideway being pivotable by means of an electromagnet about an axis running transverse to the plane through the two drive surfaces in such a manner that, alternately, one drive surface or the other drive surface is in drive connection with the drive wheel.

The line recorder recited above can be used in evaluation devices other than those herein described. With the aid of such a line recorder there may be recorded on the recording carrier, for example a paper strip, peaks whose height is proportional to the energisation time of the electromagnet. As long as the electromagnet is energised, the motor drives, *via* the drive wheel, the carriage of the stylus in the one direction; when the electromagnet is switched off, a spring or, in the case of polarised electromagnets, an energising signal of opposite polarity, couples the opposite drive surface to the drive wheel, whereby the carriage is moved back into its starting position. The advantage of this embodiment is that the drive motor for the stylus need not have its poles reversed and the constructional expenditure for the mounting and the drive of the stylus is relatively low. With the aid of this line recorder the signal predetermined numerically or as amplitude can be recorded in the form of a peak whose length corresponds to the value when there is arranged upstream of the electromagnet a converter step which converts the value of this signal which is to be recorded into a control signal for the electromagnet whose duration is proportional to the value of the signal to be recorded. Suitable as such converter steps are, in particular, saw-tooth signal generators after which a comparator is arranged which compares the saw-tooth signal with the value of the signal to be recorded.

The drive surfaces may be toothed racks, the drive wheel being a pinion. Alternatively the drive surfaces may be friction surfaces, the drive wheel being a friction wheel.

Preferably there is provided, in the drive surface, driving the carriage into a rest position and/or maximum position, a recess releasing the drive connection to the drive wheel. Thus the drive motor need not be switched off between individual recording steps.

Expediently, the guideway is a cylindrical rod which, at one end, is mounted in a bore with interference of a flange which is not removable from the device and, at its other end, passes between the adjustable stops which limit the deflection angle of the rod. The interference of the bore of the flange allows pivotal movement of the cylindrical rod which

are limited by the stops independently of the maximum possible stroke of the electromagnet.

A substantial simplification of the line recorder results when, for example, for the advance of the recording carrier there is provided an advancing roller which is rotatably mounted, non-removably from the device, and which is coupled to prevent undesired rotation to the drive wheel *via* a step-down gear. The drive motor is then utilised both for the drive of the stylus and for the advancing of the recording carrier.

Since the axes of the advancing roller and of the drive wheel are vertical to one another, the step-down may be a worm gear whose worm is located on a shaft which also carries the drive wheel and whose worm wheel is located on an axle of the advancing roller.

A substantial improvement of the line recorder is afforced by, for example, providing at a distance from the first-mentioned advancing roller, there is rotatably mounted, non-removably from the device, a further advancing roller which is capable of being driven independently of the first mentioned advancing roller. The recording carrier, for example, the recording paper, can be brought into such a position relative to the first advancing roller that it can already be inscribed with characteristic data, for example the name of the patient, during the insertion of the test strip into the roller's receiver which is in the insertion position. The second advancing roller subsequently transports the recording carrier into the intermediate space between the two advancing rollers, from which intermediate space it may be drawn off when the pertinent test strip is in the measuring position. As recording substrate there may be provided a separate substrate arranged beside the advancing rollers; in so far as the advancing rollers may have a smooth peripheral surface which is suitable as a recording substrate, the recording carrier may be inscribed directly *via* the advancing rollers. The advancing rollers alternatively may be spiked rollers in order to exclude slippage displacements of the recording carrier.

In the illustrated embodiment there is arranged upstream of the electromagnet a converter step which converts the value of a signal to be recorded by the line recorder into a control signal for the electromagnet whose duration is proportional to the value of the signal to be recorded.

The invention is illustrated, merely by way of example, in the accompanying drawings, in which:-

FIGURE 1 is a sectional view through a device according to the present invention for evaluating urine test strips and taken along the line I-I of Figure 2,

FIGURE 2 is a sectional view of the device of Figure 1 along the line II-II,

FIGURE 3 is a diagrammatic representation of one embodiment of a drive device for use in the device of Figures 1 and 2,

FIGURE 4 is another embodiment of part of a drive device for use in the device of Figures 1 and 2,

FIGURE 5 is a diagrammatic representation of a pilot card arrangement used for the control of a reflex photometer of the device of Figures 1 and 2,

FIGURE 6 shows a partially exploded sectional representation of a line recorder taken along the line VI-VI in Figure 7, and

FIGURE 7 is a plan view of the line recorder taken along the line VII-VII in Figure 6.

An automatically operating device according to the present invention for evaluating urine test strips, and shown in Figures 1 and 2, has a substantially cylindrical roller 1 whose axle 3 is rotatably mounted substantially horizontally in U-shaped trestles 5 which are upwardly open on a chassis 7. The roller 1 has several trough shaped receivers 9 for urine test strips 11; these receivers in the peripheral direction of the roller 1 are angularly offset relative to one another and extend parallel to the axle 3. The roller is rotated stepwise by a drive device which is explained in detail hereinafter with reference to Figure 3, so that the urine test strips 11 inserted in an insertion position fixed on the upper side of the device through a cut-out 13 in a removable cover 15 are transported within a predetermined length of time into a measuring position offset by 90° in which the test strips lie opposite a measuring head 17 of a reflex photometer not otherwise shown in detail. The urine test strips 11 transported from the upper side to the lower side of the roller 1 in the course of the further rotation of the roller fall out of the receivers 9 and are caught by a collecting tray 19. In order to prevent premature release and to press the urine test strips 11 into the measuring position against the bottom of the receivers 9, a multi-part comb 21 is provided. The comb 21 comprises laminar fingers 23 in the peripheral direction on both sides of the measuring position, the fingers gripping, in manner not shown in detail, in each case between test areas 25 of the individual test strips 11, which test areas 25 are arranged in the direction of the axle 3 at a distance beside one another. Furthermore, the comb 21 comprises elastic plastics filaments 27 which are stretched tangentially to the surface of the roller 1 in the peripheral direction of the roller between strips 29 of a holder 31 which is held on the axle 3 and is shown by a dash-dot line in Figure 2. The filaments 27 are, as shown in Figure 1, guided in peripheral grooves 33 of the roller 1 between the test area 25. The peripheral grooves are bounded axially on both sides by ribs 35 and reach to the bottom of the receivers 9, so that the test strips 11, by reason of the intrinsic elasticity of the filaments 27 which are slightly offset towards the axle 3, are held in the receivers 9.

On the peripheral surface of the roller 1 there are provided guide surfaces 37, 39 which run in the peripheral direction and roll off/on guide rollers 41, 43 rotatably mounted on the chassis 7. Approximately diametrically opposite the guide rollers 41, 43, pressure rollers 45, 47 are rotatably mounted on arms 49. The arms 49 are pivotably mounted on a common axle 51 which is mounted in the chassis 7 and ar in each case pre-tensioned in the direction towards the roller 1 by a spring 53 which acts between the respective arm 49 and the chassis 7; with this pretensioning, the pressure rollers 45,47 press the roller 1 against the guide rollers 41,43. While the pressure roller 45 lies against the guide surface 37 of

the guide roller 41, the pressure roller 47 lies against the locking path with locking recesses 57 which are distributed over the periphery of the roller 1 in manner corresponding to the receivers 9. The pressure roller 47 fixes the rotation positions of the roller 1 relative to the measuring position. The roller 1 together with the holder 31 can, after removal of the cover 15, be taken out of the device with no problem and, for example, be cleaned. After insertion of the roller 1, the guide rollers 41, 43 and pressure rollers 45, 47 automatically lead the roller 1 again into the correct position relative to the measuring head 17.

The measuring head 17 is slidably mounted on guides 59 parallel to the axle 3 of the roller 1. For the drive, an electric motor 61 is provided which rotates in the same direction and which, as can best be seen from Figure 3, drives, *via* a claw coupling 63, a worm 65 of a worm gear whose worm wheel 67 is coupled, in manner secure against undesired rotation, to a deflecting wheel 69 of an endless toothed belt 73 which is mounted parallel to the guides 59 by means of a further deflecting wheel 71. The measuring head 17 is coupled in articulated manner to the endless toothed belt 73 *via* a rod 75. The rod 75 is hinged to a transverse pivot 77 which is held on the outside of the endless toothed belt 73. The movement in the same direction of the endless toothed belt 73, which movement is indicated in Figure 3 by arrows 79, is converted by means of a rod 75 into a to-and-fro movement of the measuring head 17 along the guides 59.

The rod 75 is arranged laterally to the endless toothed belt 73 and is prolonged by a switching arm 81 which, during deflection of the transverse pivot 77 by the deflecting wheel 71, executes a switching movement directed from below to above during which it switches forward a switching gearwheel 83 which is rotatably mounted transverse the axis of rotation of the deflecting wheel 71 on the chassis 7. The switching gearwheel 83 meshes with a gearwheel 85 which is held coaxially with, and secured against undesired rotation on a roller 1. The switching arm 81, the switching gear 83 and the gearwheel 85 are so dimensioned that the roller 1 is rotated by the angular distance of two receivers 9 with each switching stroke of the switching arm 81. The motor 61 may be operated continously when the number of revolutions of the motor 61 or the step-down ratio of the worm gear is so chosen that the endless toothed belt 73 revolves exactly so often within each length of time which is prescribed for the test reaction of the urine test strips that the urine test strip is transported from the insertion position into the measuring position.

The switching gearwheel 83 shown in Figure 2 is switched forward by one tooth with each switching stroke of the switching arm 81. During switching forward, in each case one tooth engages in the gearwheel 85. Figure 4 shows a switching gearwheel 87 which may be used instead of the switching gearwheel 83. The switching gearwheel 87 is actuated by a switching arm having the same function as the switching arm 81 and meshes with a gearwheel 91 corresponding to the gearwheel 85. The gearwheels 87, 91 have twice the number of teeth compared to the gearwheels 83, 85; the switching gearwheel 87 is so constructed and the switching stroke of the switching arm 98 is so dimensioned that the switching gearwheel 87 is rotated by in each case two teeth per switching stroke. The advantage of the embodiment according to Figure 4 is the more uniform force engagement of the gearwheels 87, 91.

Each urine test strip contains several of the test areas designated as 25 in Figure 1; each test area responds to various substances contained in the urine. The test areas 25 discolour not only in dependence on the concentration of the substances in the urine but also in dependence on the reaction time. The individual test areas of each test strip have, as a rule, different reflectance spectra whose maxima lie at different wavelengths. The measurement of the reflectivity for the individual test areas is preferably effected at wavelengths in the range of maximum reflectance. The measuring head 17 therefore contains two monochromatic light sources 93,95 which illuminate with focused monochromatic light of different wavelength the middle of the test areas which are present in the measuring position. The incidence angles of the light sources 93, 95 are equal, so that the directly reflected light ray of, in each case, the one light source is reflected towards the other light source. Arranged vertically over the middle of the test areas which are present in the measuring position is a photocell 97 between the light sources 93, 95; the light-sensitive surface of the photocell which surface faces a test area receives and, by reason of the size of this surface, integrates to a certain extent, the light reflected from the surface of the test area. In operation, in each case one of the light sources 93 or 95 is switched on; for each test area, that light source is switched on whose light wavelength lies closer to the maximum of the reflectance spectrum of the reaction colour on the test area. The light sources may be constructed as light emitting diodes which, in order to increase the illuminating power, are operated in pulse operation. Preferentially, the one light source emits green light, in particular with 560 manometres wavelength, while the other light source emits red light, in particular with a wavelength of 635 namometres.

The number of test areas per urine test strip may vary. In order to characterise the beginning of the series of test areas on the test strip, each test strip carries a black bar 99 (Figure 1) which, *via* the measuring head 17, generates, in an electrical control (not shown in detail), of the device, a synchronisation signal which designates the beginning. The bar 99 is followed by a white test area 101 which does not react with the substances of the urine and whose reflectivity is measured by means of the measuring head 17 and stored in the reflex photometer. The stored value of the reflectivity of the white test area 101 serves in known manner as comparison magnitude in the subsequent measurement of the reflectivity of the test areas 25; the stored value is utilised for the compensation of measurement errors; in particular, it is substracted from the measured values. In this manner, for example the measurement errors caused through the urine coloration can be eliminated. The control of the measur-

ing head 17 is effected by means of an exchangeable pilot card 103 which is coordinated with the respective nature of the test strip and is pushed in between two diaphragms 107 which are arranged in the light path and are held on the measuring head 17 light barrier 105. The diaphragm 107, like the pilot card 103, consist of opaque material and have, as can be seen from Figure 5, windows 109 which at places which overlap one another unblock the light ray of the light barrier 105.

The windows of the diaphragms 107, represented by an unbroken line in Figure 5, are arranged at the distance of the test areas 25 from one another. The windows of the pilot card 103, which is drawn in broken lines in Figure 5, are so shaped that they in each case unchangingly do not shade one of the two edges lying in the longitudinal direction of the test strip, in Figure 5 the edge III of the windows of the diaphragms 107, which edge III is in each case drawn on the left, so that these edges III generate, *via* the light barrier 105, a synchronisation signal which designates the position of the measuring head 17 relative to the test areas 25. The distance between the reference edge 111 of the diaphragms 107 and, in the window, the oppositely located edge of the pilot card 103 forms an information which can be scanned by the light barrier 105. For example, the information may be so coded that a completely open window of the diaphragms 107, as is represented at 113 in Figure 5, corresponds to the absence of a test area, whereas the shading of that third of the window which lies opposite the reference edge 111, as for example at 115, indicates the presence of a test area. The middle third of each window may be utilised for the control of the monochromatic light sources 93 or 95 of the measuring head 17. For example, it may be provided that a shading 117 of the middle third of the window of the diaphragms 107 leads to the switching arm of the light source 93, whereas, in the case of the unblocked middle third 119 of the window of the diaphragms 107, the light source 95 is switched on. In order to be able to detect whether the pilot card is pushed in between the diaphragms 107 in manner correctly co-ordinated relative to the control bar 99, the diaphragms 107 contain at both ends windows 121 with which, however, a corresponding window is co-ordinated on only one side of the pilot card 103. The oppositely located window 121 of the diaphragms 107 is shaded by the pilot card 103.

In order to record the measured results determined for the individual test areas, there is provided a line recorder which is represented in Figures 6 and 7 and which writes, on a pin feed fanfold 123, peaks 125 whose length corresponds to the measured value. The pin feed fanfold may be divided up by perforations, in a manner which is not represented in detail, into individual sheets which carry in each case the peaks for all test areas of a test strip, including suitably printed-on scale lines.

The line recorder has a spiked roller 131 which is rotatably mounted in a chassis 129 of the recorder and which engages in transportation holes 127 of the pin feed fanfold 123 and which pushes the pin feed fanf ld und r a stylus 33 in longitudinal direction of th fanfold. The stylus is clamped on a holder 135 which, in turn, is resiliently mounted in hinged manner on a carriage 139 which is slidable along a guide rod 137. The guide rod 137 lies in a plane parallel to the axis of rotation of the spiked roller 131 and is pivotable about an axis vertical to this plane in an oversize bore of a flange 141 projecting from the chassis 129. Securing rings 143 fix the guide rod 137 in axial direction. A guide roller 144 which guides the carriage 139 on the side opposite the guide rod 137 prevents pivotal movements of the carriage 133 about the guide rod 137. The pivotal movement of the guide rod 137 is limited by a double stop 145 which is adjustable and fixable on all sides in the pivot plane. Opposite the flange 141, there acts an armature 147 of an electromagnet 149 which, when energised, pulls the armature 147 and thus the guide rod 137 against the action of a predetermined spring 151 from the one stop surface of the double stop 145 to the oppositely located stop surface.

The carriage 139 has two toothed racks 153,155 which face one another and are arranged at a distance from one another and run parallel to the guide rod 137. Between the toothed racks 153, 155 there acts a pinion 161 driven, *via* a claw coupling 157, by a motor with unchanging direction of rotation which, in the case of non-energisation of the electromagnet 149, engages in the toothed rack 155 and, in the case of energisation of the electromagnet 149, engages in the toothed rack 153 and, accordingly, pushes the carriage 139 to and fro along the guide rod 137.

In order to record a peak similar to the peak 125, the electromagnet 149 is energised for a duration of time proportional to the measured value which is to be recorded. As long as the electromagnet 149 is energised, the pinion 161 is in engagement with the toothed rack 153 and drives the carriage 139 and thus the stylus 133, starting from the resting position of the carriage, to the right, as is represented in Figure 6 by an arrow 163. When the energising signal of the electromagnet 149 is switched off, the pretensioning spring 151 pivots the guide rod 137 upwardly and the pinion 161 meshes with the toothed rack 155, whereby the carriage 139 is pushed back into the resting position. In a position corresponding to the resting position of the carriage 139, the toothed rack 155 contains a recess 165 in which the pinion 161 may rotate freely. The motor 159 need therefore not be switched off in the resting position of the carriage 139. Insofar as the reflex photometer emits signals whose voltage amplitude or current amplitude is proportional to the measured value, a converter 167 must be arranged upstream of the electromagnet 149, which converter 167 converts the value of the signal to be recorded into an energising signal for the electromagnet 149 whose energisation duration is proportional to the measured value to be recorded. The converter 167 may for example consist of a saw-tooth generator which is followed by a comparator which compares the saw-tooth signal with the signal to b recorded and energises the electromagnet 149 as long as the saw-tooth signal is smaller than the signal to be recorded. Since the pinion 161 can rotate freely in the recess 165 in the resting position of the carriage 139, the electric motor 159 may also be utilised for the drive

of the spiked roller 131. The shaft of the spiked roller 131 carries for this purpose a worm wheel 169 which meshes with a worm 171 which, together with the pinion 161, is located on a common shaft driven by the motor 159.

In order to identify the individual sections of the pin feed fanfold 123 already during insertion of the pertinent urine test strip, for example to be able to inscribe the sections with the name of the patient, a second spiked roller 173 is provided which is arranged at a distance from the spiked roller 131 and is driven, *via* a worm gear 175, by an electric motor 177 independently of the spiked roller 131. The electric motor 177 is so controlled by the control of the evaluation device, which control is not represented in detail, that a field 179 intended for inscription on each section of the pin feed fanfold 123 is always in recording position on the spiked roller 173 when the pertinent urine test strip is inserted into the receiver of the roller 1 (Figure 1), which receiver is in the insertion position. Between the two spiked rollers 131 and 173, the pin feed fanfold 123 forms a buffer loop, so that the motor 177 can be switched off during the inscription of the field 179.

CLAIMS

1. A device for evaluating test strips, for example, urine test strips, having test areas arranged beside one another along the test strip, the device comprising: a strip carrier including a roller which is rotatably mounted in a chassis and on which a plurality of receivers for test strips are arranged, in staggered manner, parallel to the axis of rotation in the peripheral direction of the roller; a reflex photometer which measures the reflection capacity of the test areas by means of a measuring head; a drive device which moves the measuring head and the strip carrier relative to one another in the longitudinal direction of the test strips, the measuring head being slidably arranged on a guideway parallel to the axis of rotation of the roller and being coupled by articulation means, which is deflectable transverse to the direction of movement, to an endless pulling element of the drive device, the endless pulling element being arranged to be driven unidirectionally; a switching gearwheel in rotary communication with the roller; and a switching arm coupled to the endless pulling element for switching forward the switching gearwheel.

2. A device as claimed in claim 1 in which the articulation means comprises a plurality of rods which are hinged at spaced apart points to the endless pulling element and to the measuring head.

3. A device as claimed in claim 2 in which the switching gearwheel is arranged beside a deflecting roller of the endless pulling element, the switching arm being held on the rods.

4. A device as claimed in claim 3 in which the switching gearwheel is arranged on the side of the deflecting roller which faces away from the endless pulling element so that the switching arm, in operation, goes past the deflecting roller.

5. A devic as claimed in any preceding claim in which the switching gearwheel is mounted for rotation about an axis parallel to the axis of rotation of the roller on the chassis and meshes with a gearwheel which is held coaxially on the roller.

6. A device as claimed in claim 5 in which the length of action of the switching arm and the number of teeth of the switching gearwheel are such that the switching gearwheel is capable of being switched forward by at least two teeth per switching movement of the switching arm.

7. A device as claimed in any preceding claim in which, for securing the test strips in the receivers of the roller, a comb is provided which is stationary relative to the chassis and whose fingers between the test areas in the peripheral direction of the roller grip round that part of the roller which faces the measuring head.

8. A device as claimed in claim 7 in which that part of the comb which in a measuring position holds the test strips in the respective receiver is formed by filaments which are stretched tangentially lying against a roller vertically to its axis of rotation.

9. A device as claimed in claim 8 in which the roller has peripheral grooves for guiding the filaments.

10. A device as claimed in claim 8 or 9 in which the roller, together with a holder for the filaments, forms a structural unit which is removable from the chassis.

11. A device as claimed in any preceding claim in which the roller has, on axially opposite sides, guide surfaces which extend in the peripheral direction for guide rollers which are rotatably mounted on the chassis and which determine the distance from the guideway of the measuring head, pressure rollers lying resiliently against that side of the roller which faces away from the guide rollers, a shaft of the roller being mounted in trestles which are open transverse to the shaft.

12. A device as claimed in any preceding claim in which the measuring head has a photocell arranged over a reflection surface of the test areas and at least two focusing, monochromatic light sources of different light wavelength which are arranged laterally to the photocell, the light rays of which sources are, in operation, directed obliquely at such angles to the reflection surface that its directly reflected light ray goes laterally past the photocell.

13. A device as claimed in claim 12 in which the reception direction of the photocell is aligned normally to the reflection surface.

14. A device as claimed in claim 12 or 13 in which the light incidence angles of the light sources are equal.

15. A device as claimed in any of claims 12 to 14 in which the light rays in the foot of a perpendicular directed by the photocell on the reflection surface impinge on the reflection surface.

16. A device as claimed in any of claims 12 to 15 in which the light sources and the photocells are so arranged in pairs that their light rays lie in one plane.

17. A device as claimed in any of claims 12 to 16 in which one light source emits red light and the other light source emits green light.

18. A device as claimed in claim 1 in which the measuring head carries transmitter and receiver of a

light barrier between which there is a diaphragm which cannot be removed from the device and an exchangeable pilot card, the diaphragm and the pilot card being arranged to control the drive device and/or the reflex photometer and having flush or at least partially overlapping windows for the light ray of the light barrier so that uniformly one of the two edges of the windows provided in the diaphragm is exposed and is arranged at the distance of test areas of the test strip to the corresponding edge of a neighbouring window.

19. A device a claimed in claim 1 in which for recording measured results, a line recorder is provided whose recording stylus is held on a carriage which is slidably guided along a guideway transversely to the advancing direction of a recording carrier, the carriage having two drive surfaces which face one another and are parallel to one another and to the direction of movement of the guideway, between the drive surfaces there being engaged a drive wheel which is rotatably mounted, non-removably from the device, which is driven in the same manner by a motor and whose diameter is smaller than the distance of the two drive surfaces, the guideway being pivotable by means of an electromagnet about an axis running transverse to the plane through the two drive surfaces in such a manner that, alternatively, one drive surface or the other drive surface is in drive connection with the drive wheel.

20. A device as claimed in claim 19 in which the drive surfaces are toothed racks, the drive wheel being a pinion.

21. A device as claimed in claim 19 in which the drive surfaces are friction surfaces, the drive wheel being a friction wheel.

22. A device as claimed in claim 19 in which there is provided, in the drive surface, driving the carriage into a rest position and/or maximum position, a recess releasing the drive connection to the drive wheel.

23. A device as claimed in any of claims 19 to 22 in which the guideway is a cylindrical rod which, at one end, is mounted in a bore with interference of a flange which is not removable from the device and, at its other end, passes between two adjustable stops which limit the deflection angle of the rod.

24. A device as claimed in any of claims 19 to 23 in which for the advance of the recording carrier there is provided an advancing roller which is rotatably mounted, non-removably from the device, and which is coupled to prevent undesired rotation to the drive wheel *via* a step-down gear.

25. A device as claimed in claim 24 in which the step-down gear is a worm gear whose worm is located on a shaft which also carries the drive wheel and whose worm wheel is located on an axis of the advancing roller.

26. A device as claimed in claim 24 or 25 in which, at a distance from the first-mentioned advancing roller, there is rotatably mounted, non-removably from the device, a further advancing roller which is capable of being driven indpendently of the first-mentioned advancing roller.

27. A device as claimed in claim 26 in which the advancing rollers have a smooth peripheral surface which is suitable as a recording substrate.

28. A device as claimed in claim 26 in which the advancing rollers are spiked rollers.

29. A device as claimed in any of claims 19 to 28 in which there is arranged upstream of the electromagnet a converter step which converts the value of a signal to be recorded by the line recorder into a control signal for the electromagnet whose duration is proportional to the value of the signal to be recorded.

30. A device for evaluating test strips substantially as herein described with reference to and as shown in the accompanying drawings.

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